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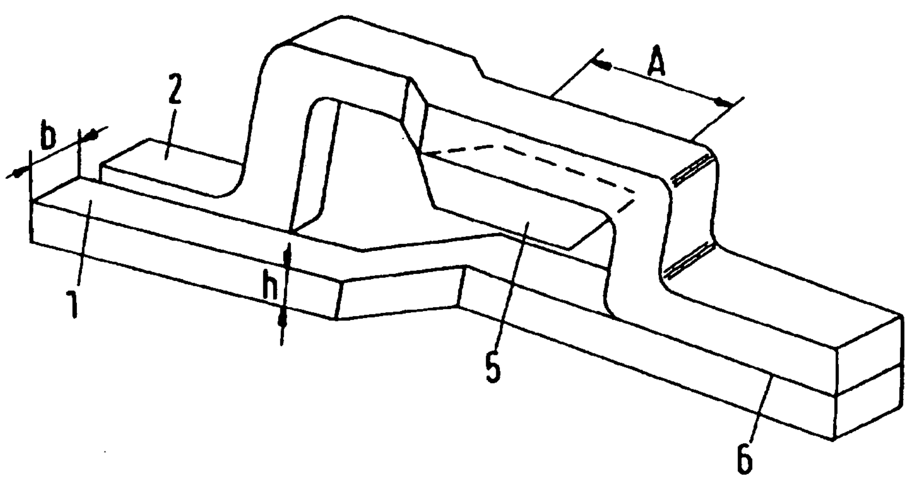

(57) Abstract

A method for transporting a fluid through a channel which is defined by circumferential walls is disclosed. Here, it is desirable to avoid contact between the circumferential walls of the channel and the fluid. To avoid this contact, an auxiliary fluid is arranged between the fluid and the circumferential walls.

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Method for transporting a fluid through a channel and apparatus for implementing the method.

The invention relates to a method for transporting a fluid through a channel which is defined by circumferential walls, and to an apparatus for implementing the method.

Fluids, that is liquids and gases, at times have to be transported through channels. An analysis apparatus is to be used here an example, where the fluid has to be conveyed through a reaction channel to a detector. At the start of the reaction channel there is arranged a mixing point in which a sample is mixed with a reagent; together, these then form the fluid. Chemical reactions take place in the fluid. The reaction product is detected in the detector.

In some reactions, reaction products can form that can have an adverse effect on the walls of the reaction channel or even of the detector. Another problem is that the fluid can be contaminated by residues of a fluid previously conveyed through the reaction channel and the detector.

The invention is therefore based on the problem of enabling a fluid to be transported through a channel without the circumferential walls and the fluid adversely affecting one another.

That problem is solved in a method of the kind mentioned at the beginning in that an auxiliary fluid is arranged between the fluid and the circumferential walls.

The fluid is therefore kept away from the circumferential walls. Contact between the fluid and the circumferential walls does not take place. Mutual influence is thus at least largely eliminated. Of course, where two fluids side by side are involved, there will always be a penetration of the two fluids one into the other, for example, through equalization of concentrations, that is, a diffusion. It will take a certain time, however, for the fluid to penetrate the auxiliary fluid to such an extent that it comes into contact with the circumferential walls of the channel or can be adversely affected in any way by the circumferential walls of the channel. The arrangement of the auxiliary fluid between the fluid and the circumferential walls is therefore sufficient for a certain time to preclude contact between fluid and the circumferential walls. The "encapsulated" fluid can comprise particles, cells or large molecules which could block the channel if the fluid is not encapsulated in an auxiliary fluid. The encapsulated fluid can have a higher optical refractive index than the surrounding auxiliary fluid, wherein light can be admitted to the encapsulated fluid. This can be exploited, for example, for optical analysis of the encapsulated fluid. An optical measurement along the channel is also possible.

It is especially preferred herein for the auxiliary fluid and the fluid to be moved jointly in a laminar flow through the channel. In a laminar flow, individual "layers" of fluid and auxiliary fluid largely remain in their original arrangement. No turbulence occurs. The only change that takes place is that, in a laminar flow, the fluid in the middle of the channel flows more quickly than at the edge. This produces the characteristic flow profile with an

extended tip. For the rest, however, the fluid remains separated by the auxiliary fluid from the walls of the channel.

In an especially preferred construction, provision is made for the fluid and the auxiliary fluid to be aligned parallel to one another before entry into the channel and for them to be kept separate from one another until their flows virtually coincide in respect of direction, and only then are they caused to lie alongside one another. In this procedure, the two fluid flows are, as it were, laminated one on top of the other. The two fluids thus lie smoothly alongside one another without turbulence forming. Mixing of the two fluids does occur as a result of diffusion, that is, as a result of equalization of concentrations in the area of their contact faces. Since, however, the contact face is relatively clearly predeterminable and the thickness of the individual fluid flows is also known, it is possible to determine in advance, for example, by estimation or calculation, how long it will take for the fluid to penetrate the auxiliary fluid completely, and thus come into contact with the walls of the channel.

It is also preferred for the flow speeds of fluid and auxiliary fluid to be brought into approximation with each other, at least in the region of their adjacent boundary surfaces, and for them to be kept separate from one another until these flow speeds also coincide to the extent necessary and only then are they brought into contact with one another. Since the two fluid flows coincide in the same direction and at the same speed, at the moment of coincidence there is no relative movement between the two flows.

It is also preferred for the fluid to be given a flow cross-section which is in the form of a polygon, and for the auxiliary fluid to be applied to all sides. The cross-section can be produced, for example, by passing the fluid through a channel that has just this cross-section. By virtue of the construction as a polygon, the fluid is defined only by flat surfaces. The auxiliary fluid is able to apply itself to or become laminated onto these flat surfaces without problems, so that no turbulence occurs. Components of the fluid flow which are not directed parallel to the flow direction, are avoided.

It is especially preferred for the polygon to be a rectangle. After lamination of two opposite sides of the fluid with auxiliary fluid, a rectangle is still present, but with an increased thickness so that it is relatively easy to apply auxiliary fluid to the remaining free sides of the fluid without fear of disruption because of protruding portions of flow or the like.

Preferably, two opposite sides of the flow cross-section are always simultaneously provided with auxiliary fluid. In the proposed method, it is not only possible to bring two fluids, namely, the fluid and the auxiliary fluid, alongside one another; the same procedure can be implemented also for three fluid flows, so that the fluid has auxiliary fluid applied to it simultaneously from above and below and from left and right. Such a procedure shortens the flow length that is needed to encapsulate the fluid.

In an alternative construction, provision can be made for the auxiliary fluid to be caused to lie alongside the fluid from two opposite sides only, the fluid

having a narrower width than the auxiliary fluid transversely to the flow direction. In that case the overhanging edges of the auxiliary fluid will push forward over the fluid and thus come alongside each other. The fluid will also spread out laterally, however, so that such a procedure is only possible when the fluid has a small thickness and the overhanging portions of the auxiliary fluid are large, that is, the width of the auxiliary fluid is considerably larger than the width of the fluid.

The fluid and the auxiliary fluid are preferably matched to one another in respect of their physical and/or chemical properties, in particular, diffusion, optical index and/or electrical properties. Such matching of fluid and auxiliary fluid with one another can then be exploited during subsequent analysis of the fluid or its constituents in order to achieve better or more rapid results.

It is also preferred for the pressure over the fluid and the pressure over the auxiliary fluid to be kept the same. By this means it is relatively simple to ensure that the product of speed and flow cross-section of fluid and auxiliary fluid are matched to one another in such a way that a lamination of fluid and auxiliary fluid onto one another is possible without problems. If the pressure over fluid and auxiliary fluid is the same and the other flow conditions are identical, the speed will be the same for both components.

The problem is also solved by an apparatus for implementing the method, namely, in that it comprises at least one combination point which is connected to an inlet channel arrangement having at least two inlet channels, and to an outlet channel arrangement, the

inlet channels being guided parallel to one another in offset planes at least in a region upstream of the combination point, that the inlet channels in the combination point run parallel to one another in the same direction, and that a separating element is provided which extends right into a region of the combination point in which the inlet channels run parallel to one another.

Using such an apparatus the two fluid flows are, as it were, laminated one onto the other. They meet at the combination point having the same direction and the same speed. As soon as the separating element ends, each fluid flow lies smoothly on the other and a boundary surface is created. Although mixing of the fluid with the auxiliary fluid can occur by diffusion through the boundary surface, the diffusion behaviour of the two fluids is known or is determinable. By virtue of the construction of the apparatus, the diffusion surface, which is an essential factor in the progression of the diffusion, is also known.

The diffusion surface corresponds to the area of the outlet channel in which also the separating element lies. Turbulence of the two fluids is excluded. It is therefore possible to predict extremely reliably how long the fluid will be kept away from the circumferential walls of the channel.

The outlet channel arrangement is advantageously aligned in the same direction as the inlet channels. The fluids therefore flow through the apparatus substantially in one main direction. Undue deviations can be avoided, because in that case there will always be the risk that it will not be possible to predict the diffusion surface with sufficient accuracy, and

turbulence will occur. Relatively small changes in direction can be allowed, however.

The separating element is preferably in the form of a flat plate. As each fluid lies on the other, no noticeable steps occur which could lead to disturbance during lamination of the two fluids onto one another.

It is in that case preferred for the separating element to have openings which are substantially smaller than the area of the separating element exposed to the inlet channels. Despite the openings, flow of the fluid is enforced and maintained until the fluids have the same direction and optionally the same flow speed. Manufacture of the apparatus is substantially simplified with the openings. For example, it is possible to reach right through the separating element to form an inlet channel by removing material.

One liquid path preferably has a course in one plane from at least one inlet channel to the outlet channel arrangement. This simplifies manufacture. Such a channel can be easily made in a surface of a component.

The apparatus advantageously consists of a bottom part, in which parts of the inlet channel arrangement, parts of the combination point and the outlet channel arrangement are in the form of grooves open towards a join-defining surface, and of a top part, which comprises the remaining parts of the inlet channel arrangement and the remaining parts of the combination point in the form of a recess which is partly covered by the separating element, wherein top part and bottom part lie next to each other at the join-defining surface. Such a configuration allows simple manufacture and a compact construction. The

construction of the grooves in the bottom part can be carried out without difficulty by means of known techniques. Milling, etching or other material-removing techniques known from the field of semiconductors and micro-elements may be considered as examples. The recess in the top part can also be made without difficulty. Since there is only a single join-defining surface, sealing is also relatively simple.

The separating element is advantageously part of the top part. Altogether there are therefore only two parts which have to be manufactured. Even when the separating element is in one piece with the top part, manufacture is relatively simple because the separating element can have openings through which the recess can be made.

The separating element advantageously has a recess of concave or triangular construction directed towards the inlet channel arrangement. Such a recess enables the two fluids to meet in the middle of the channels earlier than at the edges. In this case the fact that in a laminar flow the flow speed is greater in the middle than at the edges has been taken into account.

In a further preferred embodiment, provision is made for the inlet channel arrangement to have three inlet channels. This provides for the lamination of three fluid layers together.

In a special construction, provision can in this case be made for the middle inlet channel, at least in the combination point, to be narrower than the two other inlet channels. It is then possible for the fluid from the middle inlet channel to be encapsulated by the two fluids from the outer inlet channels. This is readily

understandable for the covering layers top and bottom, that is to say, the two layers which lie in the respective planes fed by the two outer inlet channels. But since in the middle between these two planes only a relatively small width of the inlet fluid from the middle inlet channel is covered, at the two outer edges, the two fluids from the outer inlet channels, looking in the width direction, will draw near to one another and come into contact. This produces an encapsulation of the middle fluid by the two outer fluids.

In another or additional construction, downstream of the combination point there is arranged an additional inlet channel arrangement and combination point, the lamination action of which is rotated through 90° with respect to the first combination point. In that case, lamination occurs not only from top and bottom but also from left and right, which ultimately has the same effect. The middle fluid is then encapsulated and can no longer come into contact with the walls of the channel.

The invention is described hereinafter with reference to preferred embodiments in conjunction with the drawings, in which:

Fig. 1	is a diagrammatic representation of the combining of two fluids,
Fig. 2	is a diagrammatic perspective exploded view of an apparatus for combining two fluids,
Fig. 3	is a plan view of a separating element,
Fig. 4	is an illustration of a composite fluid structure and
Fig. 5	shows another composite fluid in cross-section.

For the following explanation, liquids are used as fluids. Gases can be brought into contact with one another equally well in the same manner, however. The "lamination" of an auxiliary fluid onto one side of a fluid is illustrated. In order completely to enclose or encapsulate the fluid about its periphery, the procedure for the other sides must be correspondingly repeated, wherein the "lamination planes" have to be rotated through ± 90° and ± 180° respectively. More than two layers can be brought into contact with one another simultaneously, of course.

Fig. 1 shows diagrammatically how two liquids 1, 2 are caused to lie alongside one another. For reasons of clarity, the illustration in Fig. 1 is shown exploded and greatly exaggerated in height. In reality, the steps illustrated are much lower. The extent by which they exceed the height **h** of a liquid layer or liquid flow is insignificant.

The two liquid flows 1, 2 flow in separate channels, so-called inlet channels 3, 4 (see Fig. 2), which together form an inlet channel arrangement. As clear from Fig. 1, the liquid flows have a width **b** and height **h**. At the start of the inlet channels 3, 4, both flows 1, 2 can flow in the same plane.

Whereas the liquid flow 1 remains in this plane and changes only inasmuch as it is displaced to the side by approximately half its width, the second liquid flow 2 is channelled into a plane that is displaced with respect to the plane of the first liquid flow 1. In that plane the second liquid flow 2 is likewise displaced to the side. As a result, the two liquid flows 1, 2 are now channelled one above the other. Since the two liquid flows 1, 2 were originally

arranged side by side, channelling the two liquid flows 1, 2 one above the other requires that they are supplied from different directions to a common region A in which they are arranged one above the other. In this region A the two liquid flows 1, 2 are now so guided that at the end they have the same flow direction. In addition, at least at their adjacent boundary surfaces the same flow speed can be set, although this is not absolutely necessary. Until this is reached, they are kept separate by a separating element 5. The separating element 5 merely has to ensure that the two currents of the two liquid flows 1, 2 do not influence each other. It is therefore possible at the end of the region A to let both liquid flows 1, 2 flow with a laminar flow, optionally at the same speed, in the same direction. When therefore the separating element 5 ends, the two liquid flows apply themselves to one another at a contact face 6. The risk that turbulence will occur in the contact face 6 between the individual liquid flows 1, 2 is extremely slight. Liquid 1 can now be regarded as the fluid, and liquid 2 can be regarded as the auxiliary fluid. When both liquids are then passed together in a laminar flow through a channel, not illustrated, liquid 2 is able to prevent liquid 1 from coming into contact with the wall of the channel along which liquid 2 is flowing. If the process described is repeated with all four sides of liquid 1, liquid 1 is completely encapsulated and is thereby prevented from coming into contact with the walls of a channel.

As mentioned above, the step which liquid flow 2 has is shown on an exaggeratedly large scale. In reality the step from the lower plane to the upper plane is only about the height **h** of the first liquid flow plus the thickness of the separating element 5. At the second

step, which returns the liquid flow 2 from the second plane to the first liquid flow 1 again, the height corresponds only to the thickness of the separating element 5.

Fig. 2 shows an apparatus which can be used to implement the sequence illustrated in principle in Fig. 1.

The apparatus 8 consists of a bottom part 11 and a top part 12 which are illustrated lifted away from one another in Fig. 2, but which in reality lie adjacent one another by way of a join-defining surface 13. For example, they can be adhesively secured to one another here.

The bottom part 11 consists, for example, of glass. One inlet channel 4, the outlet channel 7 and a part of the combination point 9 are made in the join-defining surface 13 of the bottom part, for example by milling or etching or other micro-techniques. It is easy to see that a continuous channel which runs substantially in one plane is created in the bottom part 11 by this means. The width of the channel is about 200 μm. The height of the channel in the bottom part determines the thickness of the layer of fluid 1 to be encapsulated. On the other hand, the height of the channel that passes from the bottom part into the top part determines the thickness of the "insulation layer", that is, of the auxiliary fluid. It may be desirable to make this substantially thicker. The inlet channel 3 and its subsequent channels can accordingly also have a greater height.

The top part 12, which can consist of silicon, for example, has a recess 14 for providing the combination

point 9, which recess is partly covered by the separating element 5. The separating element 5 and the top part 12 are constructed in one piece. The recess 14 also can be etched into the top part 12.

In the direction of flow upstream of the separating element 5 there is therefore an opening 16 through which the liquid from the inlet channel 3 is able to rise up into the recess 14. This rise is enforced because the inlet channel 3 ends in this region. The liquid has no other option but to pass through the opening and enter the recess.

The recess 14 furthermore has an opening 17 beyond the separating element 5 in the direction of flow, which opening forms the actual combination point 9. Here, the liquid applies itself to the liquid flow that has flowed there from the second inlet channel 4. At the end of the opening 17 the liquid flows into the outlet channel.

As one can see, the inlet channel 4 has undergone two changes of direction up to this position. It has flowed around the end of the first inlet channel 3 and then continues virtually as an extension of the first inlet channel 3. The separating element 5 is long enough for it to cover this directional change of the second inlet channel 4 completely, and does not unblock the opening 17 until the flow from the second inlet channel 4 has adjusted again so that it is flowing parallel to the front edge of the lower part 11. The flow in the recess 14 also has same flow direction. Both liquids are then flowing at the same speed and in the same direction. They can then be applied to one another without any turbulence occurring. Because of the guidance provided by the inlet channel 4, the path

which the liquid has to cover here is approximately the same length as the path of the liquid from the inlet channel 3. In principle there is no relative displacement between the two liquids 1, 2,

It is clear that further liquids 2 can be laminated onto the combined liquid 1, 2 emerging from the outlet channel 7 if there are connected downstream of the apparatus illustrated in Fig. 2 further apparatuses rotated about their respective longitudinal axis through 90°, 180° and 270° with respect to the apparatus illustrated in Fig. 2.

An apparatus as illustrated in Fig. 2 can also be modified, of course, so that at the same time two liquid flows 2 are laminated from opposite sides onto the liquid 1, namely from above and below. In that case it would be necessary for the channel 4, 7 to be covered on both sides by a top part with recess and combination point.

Fig. 2 illustrates diagrammatically that the separating element 5 is in the form of a flat plate which has openings. These openings 20 are shown more clearly in Fig. 3. Here, each of the two inlet channels 3, 4 is guided into region A with a change in direction. In order to make the different planes clear, one inlet channel 3 is illustrated with solid lines, whilst the other inlet channel 4 is illustrated with broken lines.

The openings 20 are shown exaggeratedly large for reasons of clarity. In reality, the openings 20 are much smaller. Their total area is substantially smaller than the remaining area of the separating element. These openings serve for etching out of the recesses 14 in the top part 12. They are still small

enough, however, for no premature mixing of the individual liquid flows in the inlet channels 3, 4 to take place before the flows have become matched again in respect of speed and direction. The openings as shown run at an acute angle to the outlet channel 7. They can also be arranged at right angles thereto, however, or even run in the direction of the outlet channel; in the latter case there is a better pressure equilibrium on both sides of the separating element 5.

As is also clear from Fig. 3, the separating element 5 has a triangular recess 21 at its end in the direction of flow. There, the two liquids are able to lie alongside one another even earlier. This takes account of the fact that the flow speed of laminar flows is greater in the middle than at the edge.

With such an apparatus, or more accurately, with several such apparatuses arranged one behind the other, with their lamination planes rotated with respect to one another, one liquid can be encapsulated inside other liquids. This will be explained in greater detail with reference to Fig. 4. The liquid 22 to be encapsulated is shown hatched. The encapsulating liquids are shown blank.

For encapsulation, first of all three liquid flows are provided, of which the middle one is the liquid 22, whilst the two outer ones 23, 24 are formed by the encapsulating liquid. These three liquid flows 22, 23, 24 are laminated onto one another by a mixer, as illustrated in Fig. 2. Here, the lamination can be effected both in combination points arranged one after the other and in combination points having three inlet channels. When the liquid 23 is denoted as the upper liquid and the liquid 24 is denoted as the lower

liquid, in a following step two further flows of liquid 25, 26 are laminated from left and right onto the combined liquid 22-24, so that finally the end flow of liquid 27 is created, shown on the right in Fig. 4. In such an encapsulation process, the layers of the encapsulating liquids will be selected to be sufficiently thick to avoid contact of the encapsulated liquid with the walls of a channel, not illustrated, even in the event of a diffusion through the encapsulating liquids. Since the individual surface through which diffusion can be effected and the layer thicknesses can be predetermined relatively accurately, however, the time for which the liquid 22 will be encapsulated by the other liquids 23-26 can also be estimated relatively accurately.

If the liquid is allowed to flow through such a mixer (Fig. 2) in the reverse direction, that is, the outlet channel 7 is used as an inlet, the encapsulated fluid can be separated again, that is, separated from the auxiliary fluid. The dimensions of the channels may possibly have to be altered in dependence on the diffusion that has already taken place. The separating element 5 then serves to isolate the auxiliary fluid from the fluid.

Fig. 5 shows another embodiment for encapsulation, in which the liquid 22 is encapsulated only by two liquids 23, 24. For that purpose, in principle the only requirement is that the width of the liquid flow 22 is less than that of the two other liquid flows 23, 24. In that case the surrounding liquids 23, 24 will advance at least also beyond a part of the height of the liquid 22, then lie on one another subsequently. It should be pointed out, however, that here, in the region of the narrow sides, the separating face between

the individual liquids 22, 23 and 22, 24 is not so accurately predeterminable. Such an encapsulation can be achieved with the necessary reliability only if the height of the liquid 22 is very small in relation to its width.

Patent Claims

1. Method for transporting a fluid through a channel which is defined by circumferential walls, characterized in that an auxiliary fluid is arranged between the fluid and the circumferential walls.

2. Method according to claim 1, characterized in that the auxiliary fluid and the fluid are moved jointly in a laminar flow through the channel.

3. Method according to claim 1 or 2, characterized in that the fluid and the auxiliary fluid are aligned parallel to one another before entry into the channel and are kept separate from one another until their flows virtually coincide in respect of direction, and only then are they brought into contact with one another.

4. Method according to claim 3, characterized in that the flow speeds of fluid and auxiliary fluid are brought into approximation with each other, at least in the region of their adjacent boundary surfaces, and they are kept separate from one another until these flow speeds also coincide to the extent necessary and only then are they brought into contact.

5. Method according to one of claims 1 to 4, characterized in that the fluid is given a flow cross-section which is in the form of a polygon, and the auxiliary fluid is applied to all sides.

6. Method according to claim 5, characterized in that the polygon is a rectangle.

7. Method according to claim 5 or 6, characterized in that two opposite sides of the flow cross-section are always simultaneously provided with auxiliary fluid.

8. Method according to one of claims 1 to 7, characterized in that the auxiliary fluid is caused to lie alongside the fluid from two opposite sides only, the fluid having a narrower width than the auxiliary fluid transversely to the flow direction.

9. Method according to one of claims 1 to 8, characterized in that the fluid and the auxiliary fluid are matched to one another in respect of their physical and/or chemical properties, in particular, diffusion, optical index and/or electrical properties.

10. Method according to one of claims 1 to 9, characterized in that the pressure over the fluid and the pressure over the auxiliary fluid are kept the same.

11. Apparatus for implementing the method according to one of claims 1 to 10, characterized in that it comprises at least one combination point (9) which is connected to an inlet channel arrangement having at least two inlet channels (3, 4), and to an outlet channel arrangement (7), the inlet channels (3, 4) being guided parallel to one another in offset planes at least in a region upstream of the combination point (9, 10), that the inlet channels (3, 4) in the combination point run parallel to one another and in the same direction and in that a separating element (5) is provided which extends right into a region (A) of the combination point in which the inlet channels (3, 4) run parallel to one another.

12. Apparatus according to claim 11, characterized in that the outlet channel arrangement (7) is aligned in the same direction as the inlet channels (3, 4).

13. Apparatus according to claim 11 or 12, characterized in that the separating element (5) is in the form of a flat plate.

14. Apparatus according to one of claims 11 to 13, characterized in that the separating element (5) has openings (20) which are substantially smaller than the area of the separating element (5) exposed to the inlet channels (3, 4).

15. Apparatus according to one of claims 11 to 14, characterized in that one liquid path has a course in one plane from at least one inlet channel (4) to the outlet channel arrangement.

16. Apparatus according to one of claims 11 to 15, characterized in that it consists of a bottom part (11), in which parts of the inlet channel arrangement (3, 4), parts of the combination point (9, 10) and the outlet channel arrangement (7) are in the form of grooves open towards a join-defining surface (13), and of a top part (12), which comprises the remaining parts of the inlet channel arrangement (3) and the remaining parts of the combination point (9, 10) in the form of a recess (14) which is partly covered by the separating element (5), wherein top part (12) and bottom part (11) lie next to each other at the join-defining surface (13).

17. Apparatus according to claim 16, characterized in that the separating element (5) is part of the top part (12).

18. Apparatus according to one of claims 11 to 17, characterized in that the separating element (5) has a recess (21) of concave or triangular construction directed towards the inlet channel arrangement.

19. Apparatus according to one of claims 11 to 18, characterized in that the inlet channel arrangement has three inlet channels.

20. Apparatus according to claim 19, characterized in that the middle inlet channel, at least in the combination point, is narrower than the two other inlet channels.

21. Apparatus according to one of claims 11 to 20, characterized in that downstream of the combination point there is arranged an additional inlet channel arrangement and combination point, the lamination action of which is shifted through 90° with respect to the first combination point.

Fig.1

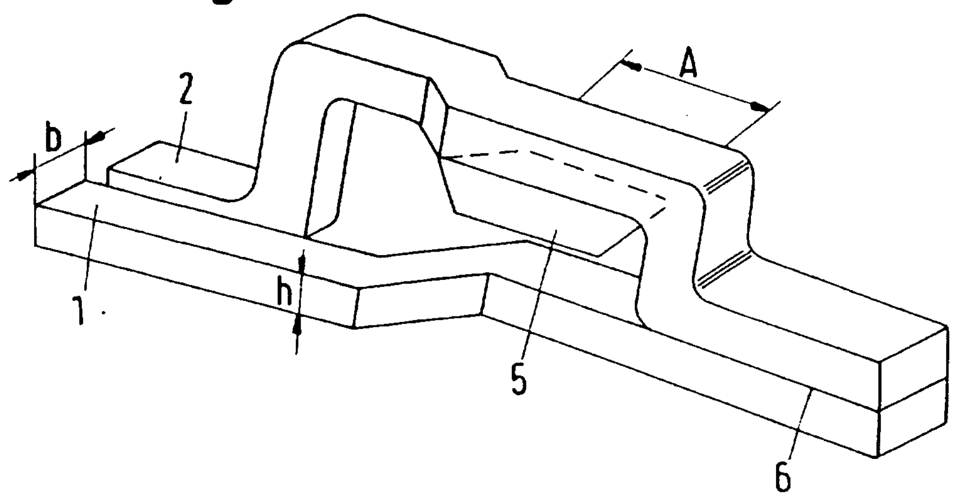


Fig.2

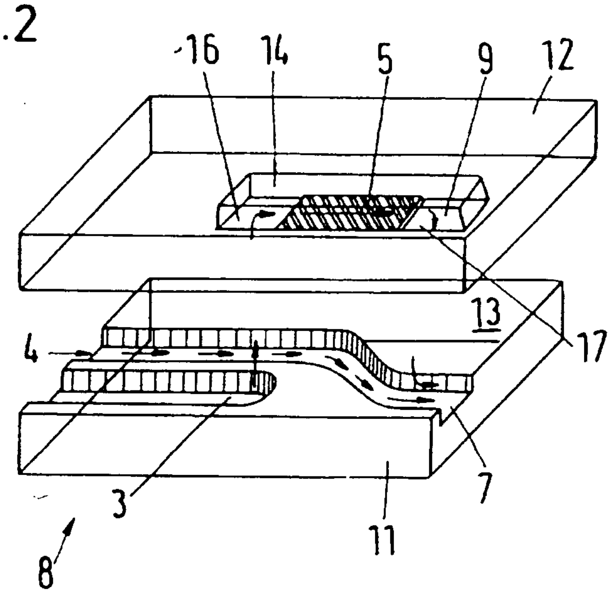


Fig.3

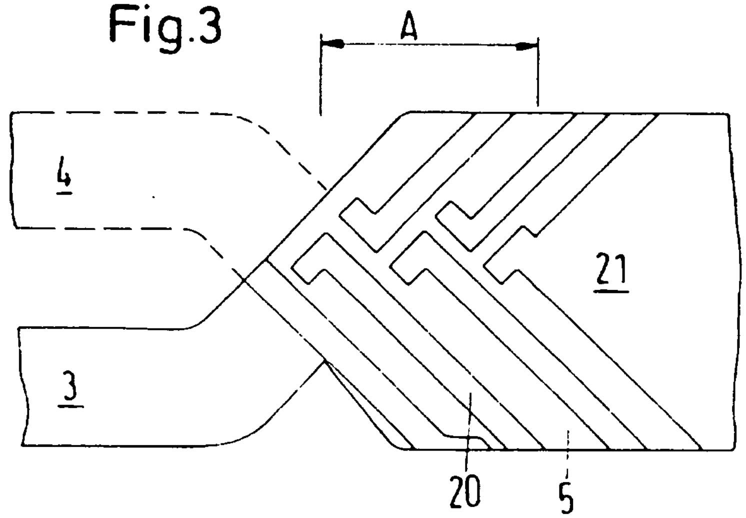


Fig.4

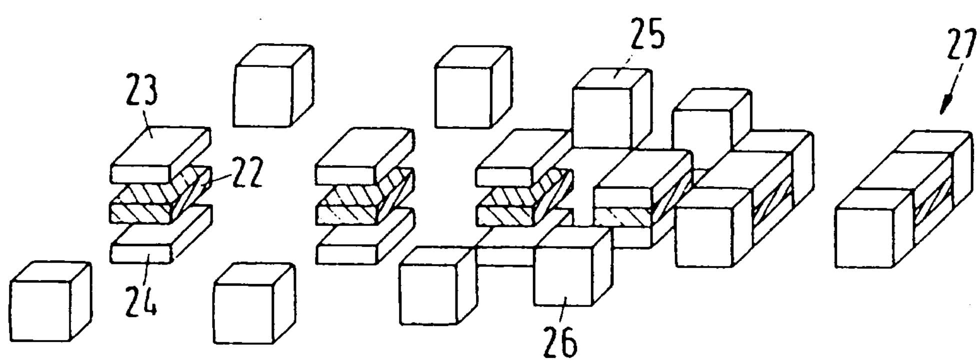
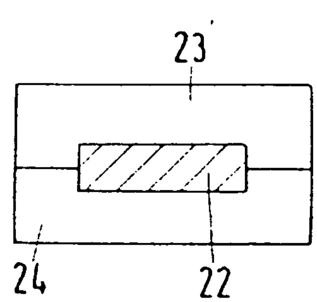


Fig.5



INTERNATIONAL SEARCH REPORT

International application No.
PCT/DK 96/00415

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: F15D 1/02, F17D 1/20
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: F15D, F17D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 2220794 A (SHELL INTERNATIONALE RESEARCH MAATSCHAPPIJ N.V.), 9 November 1972 (09.11.72), figures 1-3, claim 1 --	1-4,9-12,15, 19
X	US 3414004 A (D.M. BANKSTON), 3 December 1968 (03.12.68), figures 1-3, claim 1 --	1-4,9-12,15
X	US 3502103 A (E. VERSCHUUR), 24 March 1970 (24.03.70), figures 1-4, claim 1 -- --------	1-4,9-12,15, 19

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
13 January 1997	17 -01- 1997
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Axel Lindhult Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

Information on patent family members

28/10/96

International application No.
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Patent document cited in search report	Publication date	Patent family member(s)		Publication date
DE-A- 2220794	09/11/72	BE-A-	782362	20/10/72
		CA-A-	968009	20/05/75
		FR-A,B-	2135186	15/12/72
		GB-A-	1389232	03/04/75
		NL-A-	7105973	31/10/72
		US-A-	3826279	30/07/74
US-A- 3414004	03/12/68	NONE		
US-A- 3502103	24/03/70	DE-A,B,C	1756331	02/04/70
		FR-A-	1561818	28/03/69
		GB-A-	1168608	29/10/69
		NL-B-	154819	17/10/77
		NL-A-	6706568	11/11/68